STEVENS INSTITUTE OF TECHNOLOGY
DAVIDSON LABORATORY
CASTLE POINT STATION
HOBOKEN, NEW JERSEY

FIRST QUARTERLY PROGRESS REPORT
HYDROPLANING OF AIRCRAFT TIRES

15 January 1965

NASA Contract NSR ~~31003016~~ 31-003-016

DL Project 475/6

Object

To make a systematic experimental study of the various parameters affecting hydroplaning of aircraft tires, and to seek a quantitative theoretical description of the hydroplaning phenomenon.

Work Completed During the Period 15 October 1964 through 15 January 1965

A survey of available literature in the field revealed a great deal of previous work related to the problem at hand; a few of the more comprehensive sources are listed as References 1 - 5. This information is still under study and will be discussed in more detail in subsequent progress reports.

Preparations have begun for the modification of the Davidson Laboratory rolling road facility for use in the hydroplaning experiments. In order to obtain the scale speeds required to induce hydroplaning, it will be necessary to increase the power of the facility's drive system. This will be done by substituting a 25 hp DC motor already on hand here at Stevens for the 5 hp unit presently installed. A feedback system built around a motor-generator set to be obtained from U. S. Government surplus will be used to control the new drive. The existing rubber timing belt transmission also will be replaced by a higher capacity system.

In an effort to permit visual observation and recording of the tire foot print area, the possibility of replacing the existing opaque rolling road belting by a transparent belt is being explored. At present it appears that a belt possessing the appropriate mechanical and optical properties can be fabricated of nylon. Further study is needed to substantiate this, however.

Design work also has begun on two new pieces of test apparatus; a rig to constrain the test tires and to apply and measure driving or braking torque, and a device to apply the water film to the road.

A great deal of attention has been devoted to the selection of the test tires. For reasons of facility of testing, a geometric scale factor of 5:1 has tentatively been selected. An attempt to develop a quantitative model theory for the tire hydroplaning phenomenon has also been initiated, but no concrete results have been obtained to date. At the same time, however, work has begun on the more practical problem of how to produce the test tires once their required properties have been established. The possibilities of modifying commerical semi-pneumatic tires or of fabricating special tires of poly-urethane foam or some similar material are both being explored.

In conformance with current thinking[1], the tire hydroplaning problem is being considered in two distinct phenomenological classes-hydroplaning from predominantly fluid viscous pressures, and hydroplaning from predominantly fluid density pressures. The current experimental program, which is a systematic variation of parameters study, will of course encompass both classes of behavior, with perhaps greater emphasis on the viscous problem, potentially the more hazardous to vehicle operation. From a theoretical point of view, however, the hydroplaning due to density effects is much the more amenable to analysis. Therefore, in view of the exploratory nature of the present program, the initial theoretical efforts have been directed towards developing a mathematical model for this class of hydroplaning.

Some preliminary work has been carried out using the two dimensional analog of the hydroplaning problem by the conformal mapping technique[7, 8] and by the linearized acceleration potential approach. These studies were conducted in order to gain insight into the upper bound of the lift generated during hydroplaning and also to obtain a speculative estimate of the validity of the linearization process. In view of the lengthy calculations involved, the two-dimensional studies have been suspended in favor of the three-dimensional analog, which more correctly describes the physical problem. This analysis treats an idealized system consisting of a totally planing rigid body moving in shallow water at high Froude number. The problem has been formulated by means of linearized acceleration potential theory, in terms of two simultaneous integral equations with planing surface and boundary surface loading functions as unknowns.

Plans for Next Quarter

Work is continuing on the modification of the rolling road. Plans are being made for the installation of the new power supply and drive system. Design of the tire rig and water film applicator is in progress, and the feasibility of using transparent belting is under continuing investigation. Efforts are being made to develop a technique for measuring the tire foot print pressure distribution on the rolling road. Study also is continuing on the related problems of developing modelling laws and producing test tires of the required properties. Work has begun on the set up of a systematic test program for the rolling road tests.

On the theoretical end, a numerical method is being developed for the solution of the integral equations representing the three-dimensional planing surface problem. To effect the solution, it is necessary to specify the mathematical form of the unknown loading functions on the planing surface and bottom. Assumptions regarding the form of these functions will be made on the basis of known solutions to similar problems[9] in the case of the planing surface. No information exists on the analytic character of the loading on the bottom. The numerical solution technique will be programmed for high speed, high capacity digital computing equipment. The greater portion of the computer program will be independent of the hypothesized forms for the loading functions. Hence several different assumptions can be evaluated at relatively little expense once the basic technique has been developed.

A meeting between NASA and DL personnel at Langley Research Center has been scheduled for Wednesday, March 24, to discuss program progress and to map out future plans.

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